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ABSTRACT

This study investigated the effectiveness of LOGO's turtle graphics in both providing a model of systematic thought and in teaching simple geometry to young children in the second grade. The treatment given to 25 second grade students in the experimental group consisted of programming with LOGO's turtle graphics using four Apple II+ microcomputers. Students received approximately 1 hour of exposure every week for 3 months. The control group was a second grade class of 22 students from another school. Both groups were in the same school district and used the same textbooks and curriculum. The pretest and posttest scores of both groups were analyzed using dependent t-tests. The results showed that LOGO had a statistically significant effect on students' ability to think systematically and to understand certain geometric concepts. Nineteen references are listed. (Author/LMM)

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# THE EFFECT OF LOGO ON INCREASING SYSTEMATIC AND PROCEDURAL THINKING ACCORDING TO PIAGET'S THEORY OF INTELLECTUAL DEVELOPMENT AND ON ITS ABILITY TO TEACH GEOMETRIC CONCEPTS TO YOUNG CHILDREN

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This study investigated the effectiveness of LOGO's turtle graphics in providing a model of systematic thought and also its effectiveness in teaching simple geometry to young children in the second grade. The treatment given to the experimental group consisted of programming with LOGO's turtle graphics using four Apple II Plus microcomputers. Students received approximately one hour of exposure every week for three months. The pretests and post-tests of the experimental group were analyzed using dependent t tests. The results showed that LOGO had a statistically significant effect on their ability to think systematically and to understand certain geometric concepts. The control group was a second grade class which was selected from another elementary school. Both groups were in the same school district and used the same textbooks and curriculum.

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# INTRODUCTION

## The Statement of the Problem

The microcomputer has infiltrated the ranks of the normal classroom. It appears to have the potential to make a dramatic change in a large proportion of classrooms all across the country. As this occurs, the concerned educator must take a careful and critical look at this change. Change is inevitable so therefore it must be controlled and directed for the better. This type of "planned change" (Bennis, 1966) seems of particular importance in regard to the advance of microcomputers in the classroom. If the present surge of microcomputers into the schools continues, then it seems paramount to be able to exert some control over futuristic change, thus "proacting" to it rather than simply reacting to it (Lonsdale, 1971). The importance of considering the needs of our future is expressed by Toffler, (1974): "All education springs from some image of the future. If the image of the future held by a society is grossly inaccurate, its education system will betray its youth" (p. 3). This study hopes to "proact" to these possible changes by focusing on the present educational microcomputer era.

One particular movement has begun to dominate this still young educational microcomputer era. This movement involves the use of the computer programming language called LOGO which utilizes a "cybernetic animal" called simply the turtle. This language, primarily developed at the Massachusetts Institute of Technology (MIT) in the Artificial Intelligence Laboratory and the Division for Study and Research in Education (Abelson, 1982), has received the distinction of possibly being the most significant eduational software of the decade (Lough, 1983). But what exactly is

happening in the classroom with LOGO and the microcomputer?

Seymour Papert, the guiding force behind the LOGO movement, spent considerable time with Jean Piaget in Geneva, Switzerland. For this reason, LOGO has rather strong Piagetian roots. However, the philosophy of LOGO does tend to deviate from Piaget's rigid development structure. Indeed, Papert (1980) seems to make a strong point about the present and future influence of the microcomputer on change in our society. Some of his ideas are almost revolutionary in nature as evidenced by an interesting speculation in Mindstorms:

> "If computers and programming become a part of the daily life of children, the conservation- combinatorial gap will surely close and could conceivably be reversed: children may learn to be systematic before they learn to be quantitative" (Papert, 1980, p. 176).

To this researcher, that is a very powerful educational statement. So powerful, that it serves as the basis of this research study. Will deliberate and constant exposure to the programming language of LOGO close this conservation- combinatorial gap in young children? Will young children learn how to be more systematic in their thinking with LOGO than without? Is it possible for young children to go through Piaget's development hierarchy more quickly, again using LOGO as their vehicle?

The primary purpose of this study is to take a look at this philosophy behind LOGO to see if Papert's view might be valid. Therefore, the main problem to be studied here is whether young children might obtain a model for systematic thinking with LOGO and whether they could demonstrate this systematic thinking via certain determined Piagetian activities which could be tallied and scored. It is the intent of the study to present LOGO to young children with the Apple II Plus microcomputer in a fashion which is congruent to the educational philosophy of Seymour Papert.

A word of caution to all readers who are involved in this educational microcomputer euphoria, the findings to be presented here are by no means to be considered conclusive. This study is but a beginning in the process to understand the impact the microcomputer might possess in education, and in particular, elementary education. The microcomputer is a rather expensive item for a classroom or school, so the question has been raised as to whether it is money well spent. It seems that the answer lies in the thought of whether the microcomputer can achieve something in the schools which otherwise would be impossible. The market is full of ready-to-use educational software. Is this software contributing something to education which is unique and vital? Many criticize educators for using the computer as an expensive electronic workbook. Perhaps that criticism is valid. Speaking as an educator in the elementary school, this researcher has seen the frustration of teachers and administrators who are puzzled about how to use the microcomputer properly. Yet school districts buy these machines at tremendous costs even though these questions of utilization persist.

These educational dilemmas are part of the reason why LOGO was selected as the source of this study. Personal experiences in the elementary school classroom has shown this researcher that there is something different about LOGO. Something seems very worthwhile in having children interact with LOGO. This study hopes to detect and define at least part of this feeling.

## The Statement of the Subproblem

A rather obvious feature of LOGO is its strong geometric connotations. Many geometric concepts are stressed in LOGO's turtle

geometry, such as measurement of angles with degrees and measurement of length, as well as other more complicated ones, such as the concept of perspective. It is wondered what geometric concepts could be absorbed by young children and if those concepts could be transferred to other aspects of the children's environment. This speculation becomes even more interesting when the children are especially young, as in the second grade. According to child development theories of Piaget, a preoperational and concrete operational child does not view the world as being filled with rigid and fixed shapes. The child views the world with a more topological perspective where lines and angles are permitted to bend and flex (Copeland, 1979). It seemed important that this study should utilize the opportunity present and try to evaluate this possible learning. Therefore, the subproblem to be studied here is whether young children are able to assimilate some basic geometric concepts and the notion of perspective and rigidity even though their development dictates a more topological viewpoint.

It should be stressed that this study wishes to examine the learning which takes place in the LOGO environment without adults trying to "teach" certain concepts out of context. This learning should take place simply by interacting and exploring with LOGO. This is not to say that certain concepts are not part of the regular curriculum of the second grade. This study tries to control this variable by using a control group which has similar experiences to the studied group. The groups can then be compared. It must be noted that few of the concepts to be examined are stressed in the second grade mainly because of the developmental reasons already cited. This fact is an advantage in that prior exposure to these geometric concepts is virtually nonexistent and it is also a crutch in that reliable evaluative

measures are also virtually nonexistent for this age group.

Many educators will probably consider the results of the subproblem to be more "real" or relevant to their classroom needs and for that reason those results are considered very important. The subproblem deals with something which is much more tangible and identifiable as being important in the classroom. But it is hoped in this study that the other problem being studied is recognized for its implications in the total arena of child development which thus makes it far more significant.

## The Hypotheses

As for the question of whether LOGO will increase systematic thinking in young children, the hypothesis is that it will have a negligible or very small effect due to the limitations of time to be described in the next section. However, it is hypothesized that LOGO will have a highly significant effect on young children's learning of certain geometric concepts. It is hypothesized that three months is a sufficient time frame for the learning of selected geometric concepts. It is also hypothesized that three months is not an adequate time frame for LOGO to contribute a significant influence on a child's systematic thought processes.

## The Limitations

There are several limitations in this study. The first limitation to be discussed concerns the dependent measures used in the problem and the subproblem. The main problem of this study is whether LOGO has an effect on systematic and procedural thought. However, it was impossible to find a dependent measure for this which has proven completely reliable. It is recognized that something as complex as systematic thought cannot be given a single number as an evaluation. Yet the problem remains of trying to

accurately determine the child's relative level of systematic thought. The compromise solution used by this study stems from certain tests involving combinations and permutations used by Piaget in his studies of children, which will be discussed more fully later.

Another limiting factor concerns the dependent measure which tests for an understanding of basic geometric concepts. The limitation to be found here results from the lack of geometric math materials to be found at the second grade level. Again, no standard tests were found which have been used long enough to serve as reliable models. In fact, even in the textbooks used in the classrooms of the two groups, very little material is devoted to geometric concepts.

Thus, it was necessary to develop a geometric test which would be suitable for the age level and also would be a reliable measure for the data of the subproblem. Naturally, some thought had to be given to which concepts LOGO seems to stress in order to test for LOGO's effectiveness in teaching those concepts to young children. The two concepts which LOGO seems to stress most is measurement of length and measurement/recognition of angles. For this reason, a four page test was created by the researcher for this study for the purpose of measuring these two specific concepts.

Another limitation concerns the fact that it was impossible to provide random sampling for this study. The two second grade classrooms that were observed and tested (experimental and control) were chosen due to the willingness of the respective teachers and because of certain practicalities of testing within the jurisdiction of a moderate sized school district by a full-time classroom teacher. Certainly, follow-up studies should attempt to avoid this limitation at least to the extent of randomly selecting the classrooms to be involved.

The next limitation of this study is the length of time in which the study takes place. The study takes place over the span of three months. A longer time interval was not employed due to technical obstacles encountered with the microcomputer. It also should be noted that only four microcomputers were available for use in the study. Thus, the twenty six students who were being studied in the experimental group received less than desirable exposure to LOGO. This time was further limited by the fact that the machines were also shared with the rest of the school, which amounted to about 150 students.

Other limitations included all of the problems associated with conducting such research in the confines of the regular classroom and the public elementary school. This study had to deal with scheduling problems, student absenteeism, and many other variables which would not have been present in a controlled environment.

The Assumptions

The primary concern of this study is whether or not the children involved had any other intensive experience with using a microcomputer and more specifically if they had any experience with LOGO. The children in both groups had virtually no experience with microcomputers before this study. The control group's school had received several microcomputers during the school year; however, the control group itself had very little exposure to them. The control group had no experience whatsoever with LOGO according to their teacher.

The above information was gained through simple interviewing of each group. No child in the experimental group had a computer at home or any prolonged experience with one away from school. The same was true with the

control group with the exception of one boy whose family did own a small home computer. LOGO was an entity which was only encountered by the experimental group in the setting of this study. The only common base which was detected was the exposure to all of the popular video games to be encountered in stores and arcades. However, it is felt that this particular experience does not affect this study's findings significantly because this experience lacks the systematic thought processes found in actual programming. Also, many students did have the video game systems at their homes, but their use consisted of playing the arcade games only, and not of programming, according to the interviews. It appeared from the interviews that the two groups were very similar in their prior dealings with computers. It also seems important to note that the students involved in this study seem to come from relatively normal home environments and their respective classrooms seem to depict average school environments which are to be found in the public school system.

It should be noted that the setting of the experimental group occurs in a small rural village named Bluewater (population 500) about ten miles west of Grants, New Mexico. This community is located far from the usual reminders of the high technology industry. Apparently, the children's exposure to the high technology industry is much lower than in most communities. It is the opinion of the researcher that this virtual absence of electronic circuitry makes these children excellent subjects to test since their exposure to this sort of technology is isolated with this study.

Another important assumption is that the two groups had virtually the same basic material presented to them in math throughout the year. This assumption is based on talking with the teachers of the respective groups and also on the fact that the schools are in the same district and therefore

used the same math book and curriculum guides.

At the onset it was assumed that the experimental and control groups were essentially similar. After performing an independent t test on the pretest data of systematic thought based on the combination and permutation activities and the geometry test, the groups' mean scores were found to be statistically similar. (See "Treatment of the Data" for the statistical findings.) It is also assumed that neither group had received any special instruction in their respective normal classroom settings on concepts that normally would not have been covered had it not been for this study. Both groups did have the same chapter in their math books which deals with recognizing simple geometric shapes and measuring lines during the interval of this study.

Finally, it is assumed that neither classroom was chosen due to any information which would have served to bias this study in any way. The criteria used to select the two groups were based on variables totally independent of how each group might perform in this study. This study was planned, conducted and finalized in a way which served to provide an atmosphere of openness and responsibility on the part of the researcher and was not based on any information which might have served to invalidate the findings of it.

## DESIGN OF THE STUDY

### Selecting the Experimental and Control Groups

The criteria used to select the groups involved in this study were based on the limitations involved in conducting a research project within a moderately sized school district by an employee of that district. The limitations of time, no randomization of subjects, and limited exposure to

treatment, should be carefully noted by researchers who might attempt to replicate this study.

A second grade classroom at Bluewater Elementary School in the Grants Municipal School district was selected as the experimental group. This study considered the age levels to be found in the second grade as the optimal age levels to be tested (ages 7-9) since the focus of this study was on young children. The experimental group consisted of a total of 25 students, with a typical breakdown of age and sex.

The control group was selected in a similar fashion. A second grade class at Milan Elementary School, which is also in the Grants School District, was chosen as the control group. Again, its selection was based on the restrictions found in any school district and on the openness and cooperation of their teacher. The control group consisted of 22 students.

The Dependent Variable of the Problem

The dependent measure used for the problem of whether LOGO has an effect on systematic thinking and problem solving according to Piaget's development structure is a small battery of classic Piagetian activities. The activities test for systematic (procedural) thinking. It is important to note that the problem of developing objective tests in such areas as problem solving or procedural thinking is still an open question for educational researchers.

The Piagetian activities which attempt to detect the ability to think abstractly and systematically involves two tasks: one involving combinations and one involving permutations. Complete success at these two tasks require the reasoning and systematic thought processes supposedly only acquired after attaining the stage of formal operations. Since Papert feels

that LOGO supplies a model of systematic thought design, these tests seem to be a reasonable solution to the problem of developing an evaluative tool.

The activities themselves are quite simple in nature. Briefly described, the combination activity involves placing six different types of objects in as many different pairs of two as possible for a total of fifteen possible combinations. The permutation activity involves placing four types of objects in as many different orders of arrangement as possible for a total of twenty four possible permutations. In the planning of the testing for this study, it occurred to this researcher that a child might simply put the combinations and/or permutations together in a random way. This would achieve the vast majority of the possible combinations and/or permutations, however, it obviously shows no systematic or procedural thought. Therefore, the researcher compensated for this behavior by subtracting the total number of repeated pairs and arrangements from the total number of combinations and permutations found with 0 being the lowest possible score. The raw score from these two activities was simply the sum of the two individual scores. These raw scores served as the statistical basis of the main problem.

The Dependent Variable of the Subproblem

One obstacle encountered in this research study was the lack of reliable dependent measures of basic geometry concepts for young children. Very little geometry is introduced to children of this age. There were but a few very simplified measurement related activities in the textbooks used by the experimental and control groups. There was not a single tidbit dealing with the concepts of angle or degrees. This was the case in countless other sources which were used in search of some test or worksheet which could be used as a dependent measure. It was for these reasons that

the dependent measure for this study was an original test designed by the researcher.

The test consists of four pages. Page 1 deals with angles. Four angles are presented and the student is told to circle the one that is 45 , 90 , etc. Page 2 deals with the student's ability to reproduce a given angle. The students are given an angle and one ray of another with which they are to finish reproducing the given angle. Page 3 tests the child's ability to measure a given length. One line is given and the child is asked to draw another line of exactly equal length. The starting point for the child's line is also given in offset positions which forced the child to begin at a different perspective. Page 4 also deals with angles. The student is asked to rotate a given figure so many degrees to the right and left. The given figure is affectionately called "Oscar" and his nose points to the 0 heading.

The Independent Variable

The treatment given to the experimental group was the experience of programming in the computer language of Terrapin LOGO on four Apple II plus microcomputers. The four Apple II Plus microcomputers used in this study were also used by the intermediate grades of the school. For this reason, it was not possible for the experimental group to receive the amount of exposure to LOGO that might be desired or considered appropriate under controlled conditions. These four computers were spread among approximately 150 students in the school according to a set schedule.

Much care was taken in this study to make the children's LOGO experience comply with the educational philosophy of LOGO's principle developer, Seymour Papert. First, and foremost, every experience of every child with LOGO occurred while sitting in front of the computer itself. No

"second hand" sessions back in the classroom were held. If a child and instructor contemplated the turtle's fate, it was only while staring at the screen of the monitor or by walking about the room "playing turtle". The structure of the actual computer experience was totally success oriented. The experience of failure was intentionally removed from the setting. Some structure was necessary to provide creative ideas to the students. This may seem to deviate from Papert's philosophy somewhat, but for good reasons. It must be remembered that time is a problem in this experience. The students involved have only limited exposure to LOGO for about three months. The average time a student worked with LOGO per week amounted to about one hour. Thus it was necessary to develop a way to motivate the students to progress in a consistent way. So instead of allowing the children to explore with the turtle with total freedom, as Papert advocates, a different (if not sly) approach was used which still provides the child with enormous freedom.

In this study, a series of activity cards was prepared. On each card was a simple shape, such as a square. If the child successfully recreated the shape on the monitor of the computer, then a "chance slip" was awarded. This chance slip was put into a jar from which it was later used to draw for prizes. The more chance slips in the jar, the more chances to win something. The shapes on the cards were then made increasingly more complex. The skills learned on one card might be prerequisite on another. This building block method along with the reward system proved to be extremely successful. The children were not forced to complete the activity cards, just merely coaxed. If a child started a small project on their own and achieved some sort of final product, a chance slip was also awarded. Many times a chance slip was awarded if the child would try to alter

something in their design according to the instructor's direction. This was done only to achieve a concept which the child otherwise would have missed. Of all the methods tried by this researcher in other LOGO settings, this one seems to be the most successful.

After a child successfully completed several activity cards with little difficulty, the child on occasion was urged to combine these shapes in a way which would draw a certain kind of figure, such as a face from a series of squares. It was hoped that in this way the child would see a whole as composed of several distinct parts. Since LOGO is a procedural computer language, this discovery of parts is crucial to more advanced programming. Many times, a child would rebel against this type of thinking and persist in trying to draw something in a very general sort of way. When this occurred, the child was not pressured to "do it right", since it was obvious that the child was not ready for this new concept. Also, as one gets more experience with computers, there simply is no one way to "do it right". This can be a hard concept for some educators to accept. In most subjects, the children become frustrated when their way is downgraded because it is not the same as the instructor's. When programming a computer, if the desired goal is achieved, then the method employed to get there is almost irrelevant. Certainly, there are ways to program efficiently, but the end product is usually considered the most important thing.

The role played by the instructor in this study is also quite interesting. It is also quite different than the role usually played by a teacher in a public elementary school. The instructor's role here was one of technician and adviser and not of "teacher". The students turned to him in moments of desperation. He posed questions for them and methods of

programming for them to ponder. Yet, his suggestions were just that, suggestions. His way was viewed as advice and not as law.

It should not be perceived by the reader that the sessions were totally free of problems and that educational bliss was enjoyed by all. As previously mentioned, this was a "normal" second grade. Many children did their share of avoiding tasks and causing problems, but this truly was a rare occurrence. The students' motivational level for these LOGO sessions was truly astounding. But it should not be surprising. Indeed most educators would probably agree that the children in their classes are most well-behaved and task-oriented when the task is appropriate and well suited for the children. When children are allowed to manipulate their environment the interest level goes up and the learning level tends to increase.

The setting described here did prove to be a successful one based on the observations of the researcher. One can argue about the best possible method of presenting LOGO to children, but one thing must be remembered first: the experience must be dealt with in a way that is different from current orthodox educational methodology.

## Gathering the Data

The data were collected using the pretest/post-test design. Prior to the start of the treatment, the experimental and control groups were pretested using the dependent measures of the main problem and the subproblem. Both groups were tested in essentially identical fashions by the researcher. The geometry test was administered to both groups as a whole-group activity with the researcher as the instructor or teacher. The data from the main problem were collected through individual interviewing. Each student was interviewed by the researcher and each task was explained

by the researcher in a one-on-one fashion. This testing was also performed in a pretest/post-test fashion before and after the treatment of the experimental group.

Treatment of the Data

After the data had been collected and scored, it was then subjected to statistical tests in order to detect any significance. The statistical tests used for this study were independent and dependent $t$ tests.

As previously mentioned, the groups were considered to be similar in most respects. In order to substantiate this in regard to the pretest scores of both groups an independent $t$ test was performed on those data. This test supported this assumption of similarity by showing no statistical difference in the dependent measure of the main problem or the subproblem, $t(45) = -.1583$, $p > .01$ and $t(45) = .4024$, $p > .01$, respectively.

The pretest and post-test scores of the experimental group were then subjected to a dependent $t$ test as were the scores of the control group. The results of these tests are discussed in the next section.

ANALYSIS OF THE DATA

After the data from the pretests and post-tests had been collected and scored it was analyzed for statistical significance. Each group's set of pretest and post-test scores for each of the two dependent measures was subjected to a dependent $t$ test.

The pretest and post-test scores from the dependent measure of the main problem which sought to test for systematic or procedural thought will be discussed first. The experimental group's scores showed a statistically significant increase on this measure using combinations and permutations, $t(24) = 4.90$, $p < .01$. The group's means on the pretest and post-test were

11.52 and 17.6, respectively. The null hypothesis can be rejected and it can be concluded that the means are statistically different.

The control group's means on the pretest and post-test of the dependent measure of the main problem were 11.27 and 10.59, respectively. These means do not show any significant statistical difference, $t$ (21) = -.5718, $p < .01$. The null hypothesis must be accepted and it can be concluded that the means are statistically the same. As these figures show, the control group's scores actually declined somewhat on the post-test.

The results from the pretest and post-test scores on the subproblem were also quite encouraging. The respective means of the pretest and post-test scores of the experimental group were 11.4 and 14.8. These scores showed a statistically significant increase, $t$ (24) = 3.21, $p < .01$. Again, the null hypothesis can be rejected and the conclusion can be drawn that the means are statistically different.

The control group again showed no significant difference. Their mean scores on the pretest and post-test of this subproblem were 11.7 and 12.5, respectively. After performing a dependent $t$ test on this data it can be concluded that these means are statistically similar, $t$ (21) = .9287, $p < .01$. The null hypothesis must be accepted here and one must conclude that the means are statistically the same.

## Conclusions

The findings of this study tend to support the hypotheses and educational philosophy of LOGO's developer, Seymour Papert. The experimental group showed significantly positive results in the problem and the subproblem. In both problems, this study was able to reject the null hypothesis and conclude that the means showed a significant difference.

Likewise, the control group showed no statistical difference in both experiments. Therefore, it is the conclusion of this study that the independent variable, programming a microcomputer using LOGO, made a significant difference in the systematic and procedural thought patterns of young children and also made a significant contribution to their learning of basic geometric concepts.

Although this study is just a beginning in the attempt to understand the implications of using a microcomputer in the classroom, it does show that changes are taking place that otherwise might not have occurred. Let us consider the implications of the results of the two problems, starting with the subproblem.

In the subproblem the experimental group was tested for the learning of geometric concepts. Although the increase of the mean on the post-test is not staggering by a teacher's point of view (from 11.4 to 14.8) it does show a statistical difference which makes it important. It must be remembered that the subjects of this study were young children in the second grade. This increase in an age group which is supposedly not developmentally ready for such concepts deserves much attention. The group successfully showed that they were able to transfer at least some of the knowledge they gained through the exposure to LOGO to another forum such as the paper and pencil test which was developed for this study. It should further be noted that this was achieved in a rather "painless" sort of way. The children were not threatened with bad grades, severe punishment, or failure. They were not dictated to endlessly concerning complicated geometrical theorems. Instead, they simply played with the turtle. They interacted with the turtle and they seemed to communicate with the turtle. There was none of the usual excesses that are routinely present in our

public school system, and yet they learned. Perhaps this type of learning is part of the revolution that Papert speaks of.

Let us focus our attention now on the problem. The hypothesis of this study was that no difference pertaining to systematic thought would be observed due to the time limitations of the study. This was not the case as pointed out in the results. The experimental group showed a very real difference, statistically speaking, from the scores on the pretest to the scores on the post-test. A statistically more robust difference than even the results from the subproblem. The implications from these results are very far reaching into the educational world. Papert feels that as computers become more a part of everyday life the conservation-combinatorial gap will surely close. The findings presented here seem to support this conjecture. This study seems to show that LOGO's approach to presenting very abstract concepts to children in a concrete and syntonic way is quite effective. Furthermore, the children who use LOGO seem highly motivated to explore rather complicated endeavors with it even though their development dictates that their attempts should be met with utter frustration. Yet there was never any frustration which led a student to withdrawing from the experiment. Let it be stressed that the students seemed to view their LOGO time as a treat. It appeared that no student seemed to be at the saturation level with the LOGO experience.

## Recommendations

Although this study does state that children who are exposed to LOGO do acquire more systematic or procedural thought, it is believed that much more research is needed to substantiate the findings presented here. If more research concurs with the findings of this study then it seem apparent

that microcomputers do have a place in the elementary schools beyond the present use of today's educational software. If this study's results are indeed pointing in the correct direction then it seems clear that the microcomputer might achieve something in education that otherwise would not have been possible.

Undoubtedly, one viewpoint of many readers is whether these results, if valid, are desirable. Do we really want to have our children develop higher level thought processes at an earlier age which might mean that they would enter the stage of formal operations at an earlier age or at an accelerated rate? This is a question which certainly cannot be answered here. If Papert is correct about his notion that cultural insufficiencies are the cause of the present gap between concrete and formal operations, then lessening the gap by filling this cultural void with the computer seems to be very natural and developmentally sound. But if Papert is incorrect with his assumptions and the gap shortens in a premature way which deprives children of their developmental necessities then certainly we are exposing them to a developmentally threatening device. The recommendation to be made here is for more research in order to help everyone concerned understand the implications more fully. Speaking as an educator, this writer, at this point in time, feels only positive things about letting children explore the world of LOGO and having them use it to better understand the planet Earth.

Lastly, this study hopes to point a finger at every educator who is even vaguely interested in children to start taking an active role in this technological flood which is pouring into America's schools. The responsibility of utilizing this technology wisely in the classroom falls onto the educators. Teachers, administrators, and professors must work together to make this new resource live up to its potential. More teacher

training courses and seminars need to be implemented in this new area of education to make more teachers computer literate. Above all, this study recommends that all parties study the issues with an attitude of openness and sincerity. If Seymour Papert's "revolution" is required in this endeavor, then let it begin soon.

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